Fourth International Conference on Earth System Modelling
4ICESM-144, 2017

The annual cycle of the ITCZ and its changes under CO_2 quadrupling in the TRACMIP ensemble.

M. Biasutti (1) and A. Voigt (2)

(1) Columbia University, Lamont-Doherty Earth Observatory, Palisades, NY, United States (biasutti@ldeo.columbia.edu), (2) Karlsruhe Institute of Technology

TRACMIP, the "Tropical Rain belts with an Annual cycle and Continent - Model Intercomparison Project" is an ensemble suite of five experiments using idealized aquaplanet and land setups. It includes 14 atmospheric GCMs coupled to a motionless slab ocean and forced with diurnally and annually varying insolation; a Q-flux mimics the northward transport of heat by the ocean circulation and introduces the only asymmetry in the simulations. TRACMIP was designed to explore the dynamics of tropical rainfall to quadrupling CO_2 in a set up in which the energy balance of the surface is closed; here we focus on changes in the annual mean and seasonal response of the zonal mean ITCZ.

The ensemble-mean response of the annual mean ITCZ to CO_2-induced warming is to shift to the north, amplifying the pre-existing asymmetry in the basic state, but the spread across models is large. This is consistent with a similarly large scatter in the warming differential between the hemispheres; the magnitude of the shift is also modulated by the input of energy into the equatorial atmosphere, which varies greatly across models. Overall, the inter-model variance in the annual mean changes in the position of the ITCZ is explained equally well by changes in the latitude of the energy flux equator and in the magnitude of the atmospheric energy flux across the equator. The models do not show that the relationship between seasonal excursion of the ITCZ and seasonal changes in energy transport is quantitatively the same as that found between annual mean changes in forced simulation; nevertheless, there is qualitative agreement between the behavior of all TRACMIP simulations and more realistic CMIP-like configurations.

The CO_2-induced northward shift of the ITCZ is not uniform across the year, but is strongest during spring (when the climatological ITCZ is furthest to the south in these setups). The width of the ITCZ (defined as the region of net precipitation) is decreased in the annual mean, because of the sharp reduction in Southern Hemisphere precipitation during spring, but it actually increases during most months of the climatology.

We further explore how well the energetic frameworks proposed in the literature work in explaining forced changes in the seasonal cycle of the ITCZ and we diagnose what role changes in gross moist stability play in changing the seasonal relationship between energy transport and ITCZ position as the climate warms.